

Alterations in TSH and Thyroid Hormones following Mobile Phone Use

Seyed Mortavazi,¹ Asadollah Habib,² Amir Ganj-Karami,³
Razieh Samimi-Doost, Atefe Pour-Abedi,³ Ali Babaie³

Abstract

Objectives: In recent years, the widespread use of mobile phones has lead to a public debate about possible detrimental effects on human health. In spite of years of research, there is still a great controversy regarding the possibility of induction of any significant physiological effects in humans by microwave radiations emitted by mobile phones. This study aims to investigate the effects of electromagnetic fields induced by the Global System for Mobile communications (GSM) mobile phones on the Thyroid Stimulating Hormone (TSH) and thyroid hormones in humans.

Methods: 77 healthy university students participated in this study. The levels of T3, T4 and TSH were measured by using appropriate enzyme-linked immunosorbent assay (ELISA) kits (Human, Germany).

Results: The average levels of T3, T4 and TSH in students who moderately used mobile phones were 1.25 ± 0.27 ng/ml, 7.76 ± 1.73 µg/dl and 4.25 ± 2.12 µU/l respectively. The levels in the students who severely used mobile phones were 1.18 ± 0.30 , 7.75 ± 1.14 and 3.75 ± 2.05 respectively. In non-users, the levels were 1.15 ± 0.27 , 8.42 ± 2.72 and 2.70 ± 1.75 , respectively. The difference among

the levels of TSH in these 3 groups was statistically significant ($P < 0.05$).

Conclusion: As far as the study is concerned, this is the first human study to assess the associations between mobile phone use and alterations in the levels of TSH and thyroid hormones. Based on the findings, a higher than normal TSH level, low mean T4 and normal T3 concentrations in mobile users were observed. It seems that minor degrees of thyroid dysfunction with a compensatory rise in TSH may occur following excessive use of mobile phones. It may be concluded that possible deleterious effects of mobile microwaves on hypothalamic-pituitary-thyroid axis affects the levels of these hormones.

From the ¹Department of Radiology, Shiraz University of Medical Sciences, Shiraz, Iran ²Department of Medicine, Shiraz University of Medical Sciences, ³Department of Paramedical Sciences, Shiraz University of Medical Sciences, Shiraz, Iran.

Received : 05 Aug 2009

Accepted: 07 Sep 2009

Address correspondence and reprint request to: Dr. SMJ Mortazavi, Department of Radiology, Shiraz University of Medical Sciences, Shiraz, Iran.

E-mail: mmortazavi@sums.ac.ir

Mortavazi S, et al. OMJ. 24, 274-278 (2009); doi:10.5001/omj.2009.56

Introduction

Electromagnetic radiation in radiofrequency (RF) region has long been used for different types of information exchange. Rapidly increasing use of wireless communication systems has caused a growing public concern about possible health effects of electromagnetic fields (EMFs), particularly because the mobile phones operate in close proximity to the brain.^{1,2} Mobile (cell) phones are low power, single channel two-way radios that emit signals via electromagnetic waves.

The number of mobile phone users has dramatically increased throughout the world during the past decade and in some industrialized countries such as Japan and the United Kingdom, over 50% of the population use mobile phones.^{2,3} Cell phones are a relatively new technology. Therefore, scientists do not yet have long-term follow-up on their possible health effects.⁴ As physiological functions of human body are regulated by electric currents, it can be expected that placing the human body within electromagnetic field of sufficient strength may affect physiological processes.⁵

While the vast majority of the recently conducted research projects have focused on cancer, electromagnetic fields are also

suspected as potential cause of ailments such as sleep disorders, headaches or allergy-like symptoms.⁶ It was previously found that there was no association between the exposure to microwave radiation emitted by mobile phones or EMFs induced by some other major sources of electromagnetic fields and self-reported illness symptoms.⁷ It was also reported that microwave radiation emitted by mobile phones may increase the level of mercury; the most non-radioactive toxic element, released from dental amalgam restorations.⁸

Regarding the endocrine system, the sensitivity of pineal gland, pituitary gland, adrenal gland and thyroid gland as well as of the endocrine pancreas, testicles and ovaries to EMFs have been investigated.⁹⁻²¹ The thyroid gland is one of the most exposed and vital organs and may be a target for any type of electromagnetic radiation.²² It has been established that even a small change in thyroid hormone levels circulating in the blood are sufficient to alter the brain function of subjects.²³⁻²⁴

However, there is only one published paper that reports the effect of microwave radiation emitted by mobile phones on rats' thyroid gland hormones.²⁵ Considering the lack of data on the effects of GSM mobile phone-induced electromagnetic fields on the TSH and thyroid hormones in humans, the aim of the present

study is to assess the potential alterations of thyroid hormones after exposure to microwave radiation emitted by mobile phones.

Methods

Following applying medical ethics codes of Shiraz University of Medical Sciences and the informed consents of the subjects, 23 male and 54 female healthy university students participated in this study. The main characteristics of the participants are summarized in Table 1.

Table 1: Demographic Data of the Participants.

Parameter	Descriptions
No. of Participants	77
Age (Mean $\pm$ SD)	22.82 $\pm$ 2.52 Ranged 19.00-29.00
Sex	23 Males (29.9%), 54 Females (70.1%)
Marital Status	15 Married (19.5%) and 62 Single (80.5%)
Major	25 Radiology Students (33.3%) 50 Other Majors Including laboratory sciences, operating room, Nursing, obstetrics, medical records (66.7%)

Inclusion criteria included Age greater than or equal to 18 years, male or female and written informed consent. Exclusion criteria included patients with thyroid disease, using drugs that interfere in thyroid function, oral contraceptives, anticonvulsants, pregnancy and other conditions that are known to affect thyroid function tests. Random sampling was used to avoid any selection bias. A pilot study was conducted to determine the sample size.

The students were divided into 3 different groups; those whose average daily use of their mobile phones in talk mode was 5-20 minutes (Study Group 1, 25 individuals); those who used mobile phones more than 120 minutes (Study Group 2, 31 individuals) and finally, those who had not used mobile phones before the study (Control group, 21 individuals). Every effort was made to make the three groups comparable in key characteristics. In this regard, confounding factors such as exposures from other sources of RF fields in the environment that can give exposures as large as those from cell phones were studied.

On the other hand, proximity to base stations which have a huge effect on power output of phones (the adaptive power control to minimize power output and to maximize the battery life) as well as the numbers of calls being handled by a base station at any one time (traffic density) were taken into account. For each student, a questionnaire regarding his/her possible sources of exposure to electromagnetic fields or microwave radiation, specially the pattern of mobile phone use, medical history and life style was

recorded. The levels of T3, T4 and TSH were measured by using appropriate ELISA kits (Human, Germany). Relevant statistical tests (independent Student-t, ANOVA, and regression analysis) were performed using Statistical Package for Social Sciences (SPSS, version 15.0) at $P < 0.05$ as the significant level.

Results

The students who participated in this study were aged 19-29 years (22.82 $\pm$ 2.52; Mean $\pm$ SD). The average number of daily calls and the average duration of each call in the group 1 were 3.39 $\pm$ 1.87 (ranged 1-10), and 4.23 $\pm$ 2.01 (ranged 1-10) respectively. The average number of daily calls and the average duration of each call in the group 2 were 6.54 $\pm$ 5.64 (ranged 2-30), and 31.96 $\pm$ 22.31 (ranged 4-120), respectively. The average daily mobile phone use times in the study groups 1 and 2 were 12.68 $\pm$ 5.24, 147.4 $\pm$ 53.91 respectively. In group 1, the minimum and maximum period of mobile use was 6 months and 5 years (2.06 $\pm$ 1.33 years; Mean $\pm$ SD). In group 2, the minimum and maximum periods of mobile use were 1 and 10 years (2.90 $\pm$ 2.40 years; Mean $\pm$ SD) respectively.

The average levels of T3, T4 and TSH in the students of group 1 were 1.25 $\pm$ 0.27 ng/ml (ranged 0.9-2), 7.76 $\pm$ 1.73 μ g/dl (ranged 1.3-9.6) and 4.25 $\pm$ 2.12 μ u/l (ranged 1.9-10.1) respectively. The average levels of T3, T4 and TSH in the students of group 2 were 1.18 $\pm$ 0.30 ng/ml (ranged 0.8-1.8), 7.75 $\pm$ 1.14 μ g/dl (ranged 6-11) and 3.75 $\pm$ 2.05 μ u/l (ranged 1.5-10.0) respectively. The average levels of T3, T4 and TSH in the students of control group were 1.15 $\pm$ 0.27 ng/ml (ranged 0.8-1.7), 8.42 $\pm$ 2.72 μ g/dl (ranged 5.1-18.1) and 2.70 $\pm$ 1.75 μ u/l (ranged 0-6.8), respectively.

Analysis of Variance (ANOVA) test could not show any statistically significant difference among the levels of T3, and T4 in the participants of the 1st, 2nd and the control groups (Table 2).

Table 2: Comparison of T3, T4 and TSH levels in the 1st, 2nd and the Control Groups.

	T3(ng/ml)	T4(microg/dl)	TSH(MIU/L)
Group 1	1.25 $\pm$ 0.27	7.76 $\pm$ 1.73	4.25 $\pm$ 2.13
Group 2	1.18 $\pm$ 0.30	7.75 $\pm$ 1.14	3.75 $\pm$ 2.05
Control	1.15 $\pm$ 0.27	8.42 $\pm$ 2.72	2.70 $\pm$ 1.75
P-Value (ANOVA test)	NS	NS	P<0.05

NS: Not Significant

However, the observed difference among the levels of TSH in these 3 groups was statistically significant ($P < 0.05$). Taking only 2 groups into account and moving from ANOVA to t-test, the observed differences between the levels of T3, T4 and TSH in

the participants of the 1st and the 2nd groups were not statistically significant. (Table 3)

Table 3: Comparison of T3, T4 and TSH levels in the 1st and the 2nd Groups.

	T3(ng/ml)	T4(microg/dl)	TSH(MIU/L)
Group 1	1.25±0.27	7.76±1.73	4.25±2.13
Group 2	1.18±0.30	7.75±1.14	3.75±2.05
P-Value (Student's t-test)	NS	NS	NS

NS: Not Significant

In the same way, the differences between the levels of T3, and T4 in the participants of the 1st and the control groups were not statistically significant (Table 4). Similarly, the differences between the levels of T3, and T4 in the participants of the 2nd and the control groups were not statistically significant. (Table 5)

Table 4: Comparison of T3, T4 and TSH levels in the 1st and the Control Groups.

	T3(ng/ml)	T4(microg/dl)	TSH(MIU/L)
Group 1	1.25±0.27	7.76±1.73	4.25±2.13
Control	1.15±0.27	8.42±2.72	2.70±1.75
P-Value (Student's t-test)	NS	NS	P<0.01

NS: Not Significant

Table 5: Comparison of T3, T4 and TSH levels in the 2nd and the Control Groups.

	T3(ng/ml)	T4(microg/dl)	TSH(MIU/L)
Group 2	1.18±0.30	7.75±1.14	3.75±2.05
Control	1.15±0.27	8.42±2.72	2.70±1.75
P-Value (Student's t-test)	NS	NS	P<0.05

NS: Not Significant

However, the differences between the levels of TSH in the participants of either the 1st and the control groups (P<0.01); or the 2nd and the control groups (P<0.05) were statistically significant (Tables 3 and 4). The results obtained in this study are summarized in Fig. 1. Regression analysis did not show any significant relationship between the average daily call time and the levels of T3, T4 and TSH in the participants of the 1st and the 2nd groups (all mobile users). Similarly, the results did not find any

significant relationship between the average years of using mobile phones and the levels of T3, T4 and TSH in the participants of the 1st and the 2nd groups.

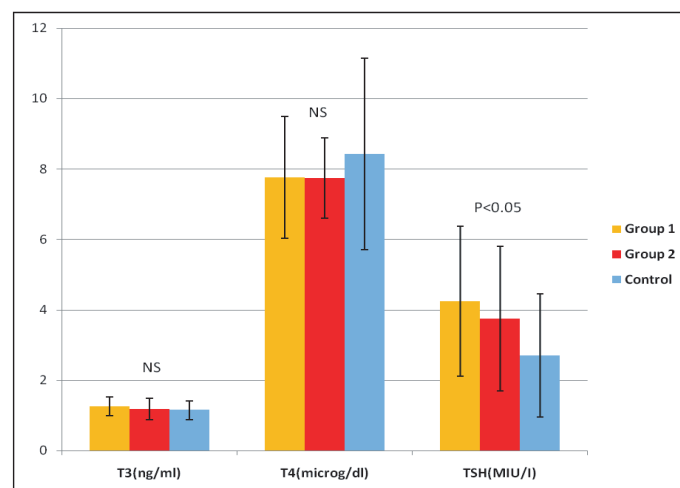


Figure 1: The Levels of T3, T4 and TSH in the 1st, 2nd and Control Groups (ANOVA test).

Discussion

Despite years of research the question of whether exposure to microwave radiation emitted by mobile phones affects human health remains unsolved. The primary outcome measures of this study were levels of TSH, and thyroid hormones T3 and T4. As far as the scope of this study, this is the first human study to assess the associations between mobile phone use and alterations in the levels of TSH and thyroid hormones. According to this study, a significant difference in the mean levels of TSH was observed between sever users and the control group as well as moderate users and the control group. Based on these results, it may be concluded that electromagnetic fields emitted by mobile phones may cause some detrimental effects on thyroid function.

TSH assessment plays a critical role in diagnosis of thyroid disease. This is due to the fact that the rate of TSH secretion is highly sensitive to the plasma concentration of free thyroid hormones. In this light, TSH assessment provides a precise and specific barometer of thyroid status of patients. Patients with thyroid dysfunction always have abnormal TSH levels. Patients with primary thyroid hypothyroidism have serum TSH level that ranges from a minimally elevated to 1000 miu/l. In general, the extent of elevation in TSH level correlates with the severity of hypothyroidism. In patients with a minimal degree of thyroid dysfunction along with few if any symptoms, the free T4 and free T4 index are typically within low normal range, while serum T3 concentrations are within the normal range. Such individuals with moderate TSH elevation are said to have subclinical hypothyroidism

if the free T4 is in the normal range. These findings indicate minor thyroid decompensation with a compensatory increase in TSH secretion.²⁶

Based on the study, the findings showed a higher than normal TSH level, low mean T4 and normal T3 concentrations in mobile users, it seems that minor degrees of thyroid dysfunction with a compensatory rise in TSH may occur following excessive use of mobile phones. It may be concluded that possible deleterious effects of mobile microwaves on hypothalamic-pituitary-thyroid axis affects the levels of these hormones. In this light, hypothalamus or pituitary gland does not play any role directly, because if there were any deleterious effects on hypothalamus or pituitary glands, TSH and T4 levels would be lower than normal, a situation that is in contrast with the study findings.

Burchard et al. investigated the effect of electromagnetic fields on blood thyroxin in dairy cattle.²⁷ Based on the results obtained in this study, exposure of dairy cattle to 10 kV/m 30 μ T EMF altered the blood thyroxin level. Although this study has some similarities with the current investigation, TSH level that is a much more sensitive criterion than T4 for assessment of thyroid function was not evaluated. The results obtained by Burchard et al. denote that EMF may have some deleterious effects on thyroid function; the same point found in the current study.

On the other hand, in another study conducted by Rajkovic et al. the sensitivity of male rat thyroid gland to an extremely low frequency electromagnetic field (ELF-EMF) was assessed.²⁸ The investigators evaluated morphophysiological criteria to determine the ability of thyroid gland to repair after exposure interval. This experiment revealed that serum T3 and T4 concentrations were significantly lower in all exposed animals except in those that were recovered morphologically but not physiologically. The results from this study as well as those obtained in the above mentioned reports; generally confirm the concept that EMF alters the thyroid function.

In another study, Koyu et al. assessed the effect of 900 MHz microwave radiation on TSH, T3 and T4 levels in rats.²⁵ In this study, exposures were made by a mobile phone simulator. It was shown that irradiated rats had significant lower levels of TSH, T3 and T4 hormones. While the current study could not detect any significant change in T3 or T4 level, Koyu reported significant lower levels. Furthermore, Koyu also reported a lower level of TSH in irradiated rats but in the current study TSH levels in mobile phone users (sever or moderate) was significantly higher than those of the control group. The findings regarding T3 and T4 levels are clearly in contrast with Koyu's results. This may be to the point that the results obtained in animal model studies cannot accurately extrapolated to humans.

A much more recent study conducted by Sinha assessed the effect of leakage microwave (2450 MHz) radiation on thyroid hormones and behavior of male rats.²² In this experiment, hormonal blood levels of T3 decreased on the 16th day and T4 increased on the 21st day. Sinha concluded that low energy microwave irradiation may be harmful as it is sufficient to alter the levels of thyroid hormones. As thyroid hormones are reported to interact with other neurohormones, the involvement of other neurotransmitters and hormonal systems in altered animal behavior following low energy, no thermal chronic microwave exposure cannot be ruled out.²² The main limitation of this study was the small sample size. Although the results should be verified in large scale future studies, these findings confirm the observations reported by only a few researchers who had previously assessed this subject.

Conclusion

Lack of ionizing radiation and the low energy level emitted from cell phones had initially led to this public perception that mobile phone use was safe. However, the dramatic increase in the use of cellular phones has generated great concerns about potential adverse effects.

Results obtained from this study, as the first human study on this topic, showed a significant alteration of TSH level in mobile phone users compared to those who had not used mobiles previously. These findings confirm early reports that showed alterations of TSH or thyroid hormones following exposure to EMF sources. Further large-scale research is required to clarify the extent of alteration caused by mobile phone use on the function of human glands.

Acknowledgements

This study was supported by a grant from Shiraz University of Medical Sciences. The authors are grateful to the students who kindly participated in this study. We especially acknowledge Dr. Hatam and Dr. S. Sharifzadeh for their support. The authors hereby confirm that none of them have any kinds of "Conflict of Interest" (such as financial, personal, political, or academic) that would potentially affect their judgment.

References

1. Marková E, Hillert L, Malmgren L, Persson BR, Belyaev IY. Microwaves from GSM mobile telephones affect 53BP1 and gamma-H2AX foci in human lymphocytes from hypersensitive and healthy persons. *Environ Health Perspect* 2005 Sep;113(9):1172-1177.
2. Takahashi S, Inaguma S, Cho YM, Imaida K, Wang J, Fujiwara O, et al. Lack of mutation induction with exposure to 1.5 GHz electromagnetic near fields used for cellular phones in brains of Big Blue mice. *Cancer Res* 2002 Apr;62(7):1956-1960.

3. Myerson SG, Mitchell AR. Mobile phones in hospitals. *BMJ* 2003 Mar;326(7387):460-461.
4. Frumkin H, Jacobson A, Gansler T, Thun MJ. Cellular phones and risk of brain tumors. *CA Cancer J Clin* 2001 Mar-Apr;51(2):137-141.
5. Karinen A, Heinävaara S, Nylund R, Leszczynski D. Mobile phone radiation might alter protein expression in human skin. *BMC Genomics* 2008;9:1-5.
6. Seitz H, Stinner D, Eikmann T, Herr C, Rösli M. Electromagnetic hypersensitivity (EHS) and subjective health complaints associated with electromagnetic fields of mobile phone communication—a literature review published between 2000 and 2004. *Sci Total Environ* 2005 Oct;349(1-3):45-55.
7. Mortavazi SM, Ahmadi J, Shariati M. Prevalence of subjective poor health symptoms associated with exposure to electromagnetic fields among university students. *Bioelectromagnetics* 2007 May;28(4):326-330.
8. Mortavazi SM, Daiee E, Yazdi A, Khiabani K, Kavousi A, Vazirinejad R, et al. Mercury release from dental amalgam restorations after magnetic resonance imaging and following mobile phone use. *Pak J Biol Sci* 2008 Apr;11(8):1142-1146.
9. Stevens RG. Electric power use and breast cancer: a hypothesis. *Am J Epidemiol* 1987 Apr;125(4):556-561.
10. Löschner W, Mevissen M. Animal studies on the role of 50/60-Hertz magnetic fields in carcinogenesis. *Life Sci* 1994;54(21):1531-1543.
11. Brainard GC, Kavet R, Kheifets LI. The relationship between electromagnetic field and light exposures to melatonin and breast cancer risk: a review of the relevant literature. *J Pineal Res* 1999 Mar;26(2):65-100.
12. Graham C, Cook MR, Gerkovich MM, Sastre A. Examination of the melatonin hypothesis in women exposed at night to EMF or bright light. *Environ Health Perspect* 2001 May;109(5):501-507.
13. Ossenkopp KP, Koltek WT, Persinger MA. Prenatal exposure to an extremely low frequency-low intensity rotating magnetic field and increases in thyroid and testicle weight in rats. *Dev Psychobiol* 1972;5(3):275-285.
14. Zagorskaya EA. Endocrine responses to low frequency electromagnetic fields of continuous and intermittent generation. *Kosm Biol Aviakosm Med* 1989;23:4-14.
15. Picazo ML, Miguel MP, Leyton V, Franco P, Varela L, Paniagua R, et al. Long-term effects of ELF magnetic fields on the mouse testis and serum testosterone levels. *Electro-Magnetobiol* 1995;14:127-134.
16. Zagorskaya EA, Klimovitsky VY, Melnichenko VP, Rodina GP, Semyonov SN. The effect of low frequency electromagnetic fields on physiological systems: a review. *Kosm Biol Aviakosm Med* 1990;24:3-11.
17. Forgács Z, Thuróczy G, Paksy K, Szabó LD. Effect of sinusoidal 50 Hz magnetic field on the testosterone production of mouse primary Leydig cell culture. *Bioelectromagnetics* 1998;19(7):429-431.
18. Burchard JF, Nguyen DH, Block E. Progesterone concentrations during estrous cycle of dairy cows exposed to electric and magnetic fields. *Bioelectromagnetics* 1998;19(7):438-443.
19. Feria-Velasco A, Castillo-Medina S, Verdugo-Díaz L, Castellanos E, Orozco-Suárez S, Sánchez-Gómez C, et al. Neuronal differentiation of chromaffin cells in vitro, induced by extremely low frequency magnetic fields or nerve growth factor: a histological and ultrastructural comparative study. *J Neurosci Res* 1998 Sep;53(5):569-582.
20. Uscebrka G, Zikic D, Matavulj M, Rajkovic V, Gledic D. Electromagnetic field effects on the morphometrical characteristics of rat adrenal glands. In: Bersani, F. (Ed.), *Electricity and Magnetism in Biology and Medicine*. Kluwer Academic/Plenum Publishers, New York, pp. 485–488, 1999.
21. Matavulj M, Rajkovic V, Uscebrka G, Lukac T, Stevanovic D, Lazetic B. Studies on the possible endocrinological effects of an 50 Hz electromagnetic field. *Centr. Europ. J. Occup. Environ. Med* 2000;6:183-188.
22. Sinha RK. Chronic non-thermal exposure of modulated 2450 MHz microwave radiation alters thyroid hormones and behavior of male rats. *Int J Radiat Biol* 2008 Jun;84(6):505-513.
23. Bauer M, Goetz T, Glenn T, Whybrow PC. The thyroid-brain interaction in thyroid disorders and mood disorders. *J Neuroendocrinol* 2008 Oct;20(10):1101-1114.
24. Bernal J. Thyroid hormone receptors in brain development and function. *Nat Clin Pract Endocrinol Metab* 2007 Mar;3(3):249-259.
25. Koyu A, Cesur G, Ozguner F, Akdogan M, Mollaoglu H, Ozen S. Effects of 900 MHz electromagnetic field on TSH and thyroid hormones in rats. *Toxicol Lett* 2005 Jul;157(3):257-262.
26. Larsen RP, Davies TF, Schlumberger MJ, Hay ID. Thyroid physiology and diagnostic evaluation of patient with thyroid disorders. In: *Williams textbook of endocrinology*. 11th edition. Saunders, pp: 319-320, 2008.
27. Burchard JF, Nguyen DH, Rodriguez M. Plasma concentrations of thyroxine in dairy cows exposed to 60 Hz electric and magnetic fields. *Bioelectromagnetics* 2006 Oct;27(7):553-559.
28. Rajkovic V, Matavulj M, Gledic D, Lazetic B. Evaluation of rat thyroid gland morphophysiological status after three months exposure to 50 Hz electromagnetic field. *Tissue Cell* 2003 Jun;35(3):223-231.